AN ENHANCED METHOD BASED ON INTERMEDIATE SIGNIFICANT BIT TECHNIQUE FOR WATERMARK IMAGES

GHASSAN NASHAT MOHAMMED

DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
2015

Permission to Use

In presenting this thesis in fulfilment of the requirements for a postgraduate degree from Universiti Utara Malaysia, I agree that the Universiti Library may make it freely available for inspection. I further agree that permission for the copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or, in their absence, by the Dean of Awang Had Salleh Graduate School of Arts and Sciences. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to:

Dean of Awang Had Salleh Graduate School of Arts and Sciences
UUMCollege of Arts and Sciences
Universiti Utara Malaysia
06010 UUM Sintok

Abstrak

Digital Watermarking Intermediate Significant Bit (ISB) adalah satu teknik baru penerapan *watermark* dengan menggantikan piksel imej asal dengan piksel yang baru. Ini dilakukan dengan cara memastikan persamaan yang nyata antara piksel baru dengan piksel asal dan pada masa yang sama, data *watermark* di dalam piksel baru tidak di ubahsuai. Salah satu teknik yang popular dalam *watermarking* adalah mengunakan *Least Significant Bit* (LSB). Ia menggunakan spatial domain yang diselitkan dalam imej LSB. Masalah yang biasa dihadapi dengan kaedah ini ialah imej tersebut mudah di ubahsuai dan, kemungkinan berlaku gangguan pada imej setelah *watermark* diterapkan. LSB boleh digunakan dengan menggantikan satu, dua, atau tiga bit; ini dilakukan dengan menukar bit tertentu tanpa apa-apa perubahan lain dalam bit piksel tersebut. Objektif tesis ini adalah untuk merangka algoritma baru bagi meningkatkan kualiti dan *robustness* imej digital *watermarking* dengan menerapkan dua bit imej *watermark* ke dalam setiap piksel. Ini dapat meningkatkan *robustness* kedua-dua imej tersebut di samping meningkatkan keupayaan *watermark* berasaskan pada teknik ISB. Walau bagaimanapun, *tradeoff* antara kualiti dan *robustness* perlu dilakukan untuk mendapatkan keseimbangan kedudukan yang terbaik untuk kedua-dua bit *watermark* yang di ubahsuai. Teknik *Dual Intermediate Significant Bits* (DISB) telah dicadangkan dalam kajian ini untuk mengatasi masalah dalam LSB. Keputusan ujian yang diperolehi daripada teknik yang dicadangkan adalah lebih baik berbanding dengan LSB dari segi *Peak Signal to Noise Ratio* (PSNR) dan *Normalized Cross Correlation* (NCC). Kajian ini juga menyumbang pada pembinaan persamaan matematik yang baru bagi tujuan untuk mengubah enam bit piksel *watermark* selepas menerapkan dua bit yang baru.

Kata kunci: Watermark, Intermediate Significant Bit, Kualiti, Robustness, Least Significant Bit.

Abstract

Intermediate Significant Bit digital watermarking technique (ISB) is a new approved technique of embedding a watermark by replacing the original image pixels with new pixels. This is done by ensuring a close connection between the new pixels and the original, and at the same time, the watermark data can be protected against possible damage. One of the most popular methods used in watermarking is the Least Significant Bit (LSB). It uses a spatial domain that includes the insertion of the watermark in the LSB of the image. The problem with this method is it is not resilient to common damage, and there is the possibility of image distortion after embedding a watermark. LSB may be used through replacing one bit, two bits, or three bits; this is done by changing the specific bits without any change in the other bits in the pixel. The objective of this thesis is to formulate new algorithms for digital image watermarking with enhanced image quality and robustness by embedding two bits of watermark data into each pixel of the original image based on ISB technique. However, to understand the opposite relationship between the image quality and robustness, a tradeoff between them has been done to create a balance and to acquire the best position for the two embedding bits. Dual Intermediate Significant Bits (DISB) technique has been proposed to solve the existing LSB problem. Trial results obtained from this technique are better compared with the LSB based on the Peak Signal to Noise Ratio (PSNR) and Normalized Cross Correlation (NCC). The work in this study also contributes new mathematical equations that can study the change on the other six bits in the pixel after embedding two bits.

Keywords: Watermarking, Intermediate Significant Bit, Quality, Robustness, Least Significant Bit.

Acknowledgement

It gives me great pleasure to express my gratefulness to everyone who contributed in completing this thesis. It was my pleasure to study under Associate Professor Dr. Azman Yasin's supervision. I'm so grateful for his support during the last four years; who was also my supervisor during my Master's study at UUM. He is like a brother to me, and for all of these, there are no words to express my gratitude for his guidance in helping me to achieve my goal. Without his valuable support, my thesis would not have been possible. I would like to thank my co-supervisor Associate Professor Dr. Akram M. Zeki for his advanced ideas and his noble mind. His continuous advice and important comments helped improve my work successfully.

To my father, whose surname I proudly carry – I am forever appreciative. I hope he is proud of me even if he is no longer with us. To my mother, who gave me life and prayed for me all the time, may Allah continuously bless her with good health. To my sisters and brothers, thanks for their love and support. To my wife Suha, who gave her time and patience during the last four years of study, I thank her from the bottom of my heart. I would also like to thank my two young babies Mohammed and Zainab, without whom my goal would not have been achieved. I dedicate this work to my family.

I'm so glad to study at Universiti Utara Malaysia (UUM). I completed both my Master's and PhD at the same university and spent a total of about five years there. During my time in UUM, I have gained a lot of friends, and studying there was like being in my hometown. My sincere gratitude to all of them for all the encouragement during my study.

Table of Contents

List of Tables

List of Figures

List of Appendices

CHAPTER ONE
INTRODUCTION

1.1 Background

Currently, digital watermarking and information hiding have become important topics of computer science due to the increasing popularity of the Internet and the critical need of data security (Chin et al, 2004).

Digital watermarking is a special case of general information hiding problem. It inserts a perceptually transparent pattern known as a watermark into an image called original or cover using an embedding algorithm in which it is undetectable to human eyes, but visible to computer processes for data declaration (Modaghegh et al, 2009).

In other words, digital watermark is a signal which is permanently embedded into digital data (audio, images, videos, and text) which can be detected or extracted later by means of computing operation to make assertion of the data. The watermark is hidden in the original data, in such a way that it is inseparable from the data and so that it is resistant to many operations which do not degrade the original data. Thus, by means of watermarking, the work is still accessible but permanently marked (Lu, 2005). This method successfully shields the copyright of the originality for media which is organization mark, for instance, in the original media. The image quality has not been corrupted through the watermarking system, and the inserted watermark should recover dependably. It is also essential for the embedded watermark to be resilient against noise and other typical image processing attacks. These attacks may be blurred

The contents of the thesis is for internal user only

References

Aarthi, R., Jaganya, V., & Poonkuntran, S. (2012). Modified LSB for Image Authentication. *International Journal of Computer & Communication Technology (IJCCT) Vol-3* (Iss-3), 62-65.

Abdullatif, M., Zeki, A. M., Chebil, J., & Gunawan, T. S. (2013). Properties of digital image watermarking. *paper presented at IEEE 9th International Colloquium on Signal Processing and its Applications, Kuala Lumpur, Malaysia*, 235-240.

Adrian, S. (2003). Enhanced Watermark Detection. *Master thesis*. University of Toronto, Canada.

Ahmad, K. A. A. a. H. A., & Gaydecki, P. (2009). A Blind Block Based DCT Watermarking Technique for Gray Level Images Using One Dimensional Walsh Coding. *IEEE International Conference on the Digital Object Identifier*, 1 - 6.

Al-Ataby, A., & Al-Naima, F. (2010). A Modified High Capacity Image Steganography Technique Based on Wavelet Transform. *The International Arab Journal of Information Technology*, Vol. 7, No. 4, 357-363.

Al-Jaber, A., and Aloqily, I. (2003). High Quality Steganography Model with Attacks Detection. *Pakistan Journal of Information and Technology*. Vol. 2 (No. 2), 116-127.

Aliwa, M. B., El-Tobely, T. E.-A., Fahmy, M. M., Nasr, M. E. S., & El-Aziz, M. H. A. (2013). A New Novel Fidelity Digital Watermarking Adaptively Pixel Based on Medial Pyramid of Embedding Error in Spatial Domain and Robust.

International Journal of Computer Theory and Engineering, Vol. 5, No. 4, 603-610.

Ansari, R., Devanalamath, M. M., Manikantan, K., & Ramachandran, S. (2012). Robust Digital Image Watermarking Algorithm in DWT-DFT-SVD Domain for Color Images. *IEEE International Conference on Communication, Information & Computing Technology (ICCICT)*, 978-1-4577-2078-9/12, 1-6.

Anwar, M. J., Ishtiaq, M., Iqbal, M. A., & Jaffar, M. A. (2010). Block-based Digital Image Watermarking using Genetic Algorithm. *IEEE.6th International Conference on Emerging Technologies (ICET)*, 204-209.

Asatryan, D., & Asatryan, N. (2010). Combined Spatial and Frequency Domain Watermarking. 1-4.

Bamatraf, A., Ibrahim, R., & Salleh, M. N. B. M. (2010). Digital Watermarking Algorithm Using LSB. *IEEE.International Conference on Computer Applications and Industrial Electronics (ICCAIE),December 5-7.*, 155-159.

Bamatraf, A., Ibrahim, R., & Salleh, M. N. M. (2011). A New Digital Watermarking Algorithm Using Combination of Least Significant Bit (LSB) and Inverse Bit. *Journal of Computing Press, NY, USA, ISSN 2151-9617, Vol 3*(Iss 4), 1-8.

Bedi, S., Tomar, G. S. & Verma, A. S. (2009). Robust Watermarking of Image in the Transform Domain using Edge Detection. *11th International Conference on Computer Modelling and Simulation, 233-238.*

Bennour J., Dugelay J. L., and Matta, F. (2007). Watermarking Attack: *BOWS contest. Proceedings of SPIE.*

Bhatnagar, G., & Raman, B. (2008). A new robust reference watermarking scheme based on DWT-SVD. *Computer Standards & Interfaces*, doi:10.1016/j.csi.2008.09.031, 1-12.

Brabin, D., & Tamilselvi, J. J. (2013). Reversible Data Hiding: A Survey. *International Journal of Innovative Research in Computer and Communication Engineering ISSN : 2320 – 9798*, Vol. 1 (Issue 3), 695-700.

Chan, C. K., & Cheng, L. M. (2001). Improved hiding data in images by optimal moderately-significant-bit replacement. *Electronics Letters*, Vol 37, No 16, 1017-1018.

Chan, C. K., Cheng, L.M, Leung, K. C., and Li, S. L., (2004). Image Hiding Based on Block Difference, in the 8 th in International conference on control, Automation, Robotics, and Vision.

Changa, C. C., Hsiaob, J. Y., and Chana, C. S. (2003). Finding optimal least significant- bit substitution in image hiding by dynamic programming strategy. *Pattern Recognition.* 36: 1583–1595.

Chen, P. C. (1999). On the Study of Watermarking Application in WWW – Modelling, Performance Analysis, and Applications of Digital Image Watermarking Systems. *Ph.D. Thesis, Monash University*.

Chen, W. Y. (2003). A Comparative Study of Information Hiding Schemes Using Amplitude, Frequecy and Phase Embeddings. *Ph.D. dissertation. Department of Electrical Engineering, National Cheng Kung University*, Tainan, Taiwan, R.O.C.

Chen, & Lu. (2012). Robust Spatial LSB Watermarking Of Color Images Against JPEG Compression. *IEEE fifth International Conference on Advanced Computational Intelligence(ICACI)*, 872-875.

Chetouani, A., Nguyen, P. B., Luong, M., & Mostafaoui, G. (2010). Content-Based Watermarking Robust to Low Bit Rate JPEG Compression. *10th International Conference on Information Science, Signal Processing and their Applications (ISSPA 2010)*, 29-32.

Cheung, W. N. (2000). Digital image watermarking in spatial and transform domains. *TENCON Proceedings*. 3: 374-378.

Chin, C. C., Guei, M. C., and Lin, M. H. (2004). Information hiding based on searchorder coding for VQ indices. Pattern Recognition Letters.

Chung, K. L., Shen, C. H., and Chang, L. C., (2001). A Novel SVD- and VQ-based Image Hiding Scheme. *Pattern Recognition Letters. 22*: 1051-1058.

Cox, I. J., Kilian, J., Leighton, T., & Shamoon, T. (1995). Secure Spread Spectrum Watermarking for Multimedia. *Proceedings of the SPIE. San Jose, 2420*, 456-459.

Dadkhah, S., Manaf, A. A., and Sadeghi, S. (2012). Efficient Digital Image Authentication and tamper localization technique using 3 LSB bit. International journal of computer science issues.

Darmstaedter, V., Delaigle, J. F., Quisquater, J. J., and Macq, B. (1998). Low Cost Spatial Watermarking. *Comput. & Graphics*. 22(4): 417-424.

Dejun, Y., Rijing, Y., Yuhai, Y., & Huijie, X. (2009). Blind Digital Image Watermarking Technique Based On Intermediate Significant Bit and Discrete

Wavelet Transform. *paper presented at IEEE International Conference Computational Intelligence and Software Engineering (CiSE)*, 1-4.

Dubolia, R., Singh, R., Bhadoria, S. S., & Gupta, R. (2011). Digital Image Watermarking by Using Discrete Wavelet Transform and Discrete Cosine Transform and Comparison Based on PSNR. *IEEE.International Conference on Communication Systems and Network Technologies*, 593-596.

Eggers, J. J., Su J. K., and Girod, B. (2000). Robustness of a Blind Image Watermarking Scheme. I*nternational Conference on Image Processing (ICIP 2000)*, Canada.

Emami, M. S., Sulong, G. B., and Seliman, S. B. (2012). "A Novel Multiple Semi-Blind Enhanced ISB Watermarking Algorithm Using Watermark Bit-Pattern Histogram For Copyright Protection", *International Journal of Innovative Computing, Information and Control ICIC International, ISSN 1349-4198* , March, vol. 8, No 3(A), pp. 1665-1687.

Fazli, S., & Khodaverdi, G. (2009). Tradeoff between Quality and Robustness of LSB Watermarking using SSIM Quality Metrics. ICMV '09. Second International Conference on Issue Date: 28-30 Dec. 2009 101-104.

Fındık, O., Babaoğlu, İ., Ülker, E., (2009). " Watermarking schema using an arTIFFicial immune system in spatial domain ", Pr*oceedings of the 2nd International Conference on Interaction Sciences: Information Technology, Culture and Human, ICIS* Seoul, Korea, November 24-26, 2, , 945-950,

Forrester, E. (2006). A Process Research Framework The International Process Research Consortium.

Fridrich, J., & Goljan, M. (1999) “Comparing Robustness of Watermarking Techniques,” SPIE Security and Watermarking of Multimedia Content, San Jose, CA, Jan 1999.

Fridrich, J., & Goljan, M. (2003). On Estimation of Secret Message Length in LSB Steganography in Spatial Domain.

Fung, A. G. C., & Junior, W. G. (2011). A Review Study on Image Digital Watermarking. *presented at the The Tenth International Conference on Networks, St. Maarten, The Netherlands Antilles.*

Ganesan, K., & Guptha, A. T. K. (2010). Multiple Binary Images Watermarking in Spatial and Frequency Domains. *An International Journal(SIPIJ) Vol.1, No.2,*,148-159.

Gao, X., Deng, C., Li, X., & Tao, D. (2010). Geometric Distortion Insensitive Image Watermarking in Affine Covariant Regions. IEEE Transections on Systems, Man, and Cybernetics Part C: Applications and Reviews, Vol. 40, No. 3, 278-286.

Geetha, Sindhu, S. S. S., Priya, B., Mubakiya, S., & Kamaraj, N. (2011). Geometric Attack Invariant Watermarking with Biometric Data - Applied on Offline Handwritten Signature. National Conference on, Computer Vision, Pattern Recognition, Image Processing and Graphics, 106-109.

Ghosh, S., Ray, P., Maity, S. P., & Rahaman, H. (2009). Spread Spectrum Image Watermarking with Digital Design. IEEE International Advance Computing Conference (IACC 2009), 868-873.

Greyscale Standard Images, http://www.dip.ee.uct.ac.za/imageproc/stdimages/greyscale/, last access 9 February 2008.

Gunjal, B. L., & Mali, S. N. (2013). Design and Implementation of Invisible and Visible Color Image Watermarking with Netbeans IDE International Journal of Computer Applications Vol 71 - NO.11 40-45.

Gong, H., Xie, S. J., Park, D. S., Yoon, S., & Shin, j. (2011). Novel robust blind image watermarking method based on correlation detector. *paper presented at IEEE International Conference on ICT Convergence (ICTC)*, 751-755.

Goyal, S., Gupta, R., & Bansal, A. (2009). Application of Genetic Algorithm to Optimize Robustness and Fidelity of Watermarked Images. International Journal on Computer Science and Engineering 239-242.

Gulati, K. (2003). Information Hiding Using Fractal Encoding. Master Thesis. Indian Institute of Technology Bombay, Mumbai.

Gunjal, B. L., & Mali, S. N. (2011). Secured Color Image Watermarking Technique in DWT-DCT Domain. *International Journal of Computer Science, Engineering and Information Technology (IJCSEIT) Vol.1, No.3*, 36-44.

Gunjal, B. L., & Mali, S. N. (2013). Handling Various Attacks in Image Watermarking. *CSI Communications*, 30-32.

Gupta, S., & Jain, S. (2010). A Robust Algorithm of Digital Image Watermarking Based on Discrete Wavelet Transform. *International Conference IJCCT Vol.1* (Issue 2, 3, 4), 222-227.

Hajisami, A., Rahmati, A., & Babaie-Zadeh, M. (2011). Watermarking Based on Independent Component Analysis In Spatial Domain. *IEEE UKSim 13th International Conference on Modelling and Simulation*, 299-303.

Hala, H., and Zayed, A. (2005). High-Hiding Capacity Technique for Hiding Data in Images Based on K-Bit LSB Substitution. *Proceedings of the 13th International Conference on Artificial Intelligence Applications*. February 23- 26. Cairo, Egypt.

Hemahlathaa, & Chellppan. (2012). A Feature-Based Robust Digital Image Watermarking Scheme. IEEE International Conference on Computing, Communication and Applications (ICCCA), 1-5.

Hsieh, C. T., Lu, Y. L., Luo, C. P., and Kuo, F. J. (2000). A Study of Enhancing the Robustness of Watermark. *ISMSE Conference*. 325-327.

http://decsai.ugr.es/cvg/CG/base.htm

Hongqin, S., & Fangliang, L. (2010). A Blind Digital Watermark Technique for Color Image Based on Integer Wavelet Transform *paper presented at IEEE International Conferen*ce for Biomedical Engineering and Computer Science (ICBECS), 1-4.

Hosinger, C., and Rabbani, M. (2000). Data embedding using phase dispersion. *presented at International Conference on Information Technology: Coding and Computing (ITCC2000).*

Ishtiaq, M., Sikandar, B., Jaffar, M. and Khan, A. (2010). Adaptive Watermark Strength selection using practice swarm optimization. *ICIC International conference, ISSN 1881-803X*, Vol 4 (No 5), 1-6.

Jadav, Y. (2013). Comparison of LSB and Subband DCT Technique for Image Watermarking. Conference on Advances in Communication and Control Systems (CAC2S), 398-401.

Jain, A. K., and Uludag, U. (2002). Hiding Fingerprint Minutiae in Images. *Workshop on Automatic IdenTIFFication Advanced Technologies.* March 14-15. Tarrytown, New York, USA: 97-102.

Jain, J., & Rai, V. (2012). Robust Multiple Image Watermarking Based on Spread Transform. *Book of Watermarking ISBN: 978-953-51-0619-7, Vol 2*, 43-64.

Jian, L., & Xiangjian, H. (2005). A Review Study on Digital Watermarking. *First International Conference on Information and Communication Technologie ICICT* 337-341.

Juergen, S. (2005). Digital Watermarking for Digital Media. University of Cooperative Education Heidenheim, Germany. ISBN:159140519X.

Jun, K. X., & Jun, D. L. (2009). Study of the Robustness of Watermarking Based on Image Segmentation and DFT. *IEEE International Conference on Digital Object IdenTIFFier ICIECS : 10.1109/ICIECS.2009.5362694* 1-4.

Kailasanathan, C. (2003). Fragile watermark based on polarity of pixel points. *Proceedings of the 3rd International Symposium on Image and Signal Processing and Analysis (ISPA 2003).*18-20 September. IEEE, 860-865.

Kao, C. H., & Hwang, R.-J. (2005). Information Hiding in Lossy Compression Gray Scale Image. *Tamkang Journal of Science and Engineering*, Vol. 8, No 2, 99 - 108.

Khodaei, M., & Faez, K. (2012). New adaptive steganographic method using least-significant-bit substitution and pixel-value differencing. *IET Image Processing*, Vol 6, (Issue 6), 677 – 686.

Kumari, Kumar, Sumalatha, & Krishna. (2009). Secure and Robust Digital Watermarking on Grey Level Images. International Journal of Advanced Science and Technology.

Langelaar, G. C., Lagendijk, R. L., and Biemond J. (1998). Removing Spatial Spread Spectrum Watermarks by Non-linear Filtering. 9th European Signal Processing Conference (EUSIPCO'98). Island of Rhodes, Greece, 2281-2284.

Langelaar, G. Setyawan, I., and Lagendijk, R. L. (2000). Watermarking Digital Image and Video Data. IEEE Signal Processing Magazine. September. 17: 20-43.

Lee, G. J., Yoon, E. J., & Yoo, K. Y. (2008). A new LSB based Digital Watermarking Scheme with Random Mapping Function. *paper presented at IEEE International Symposium on Ubiquitous Multimedia Computing*, 130-134.

Li, C. T., and Yang, F. M. (2003). One-dimensional Neighbourhood Forming Strategy for Fragile Watermarking. Journal of Electronic Imaging. 12(2): 284-291.

Liu, J. C., and Chen, S. Y. (2001). Fast two-layer image watermarking without referring to the original image and watermark. *Image and Vision Computing*. 19(14): 1083-1097.

Lin, C. C. and Tsai, W. H. (2004). Secret image sharing with steganography and authentication. *Journal of Systems and Software*. November. 73: 405–414.

Lin, K. Y., Hong, W., Chen, J., Chen, T. S., & Chiang, W. C. (2010). Data Hiding by Exploiting Modification Direction Technique Using Optimal Pixel Grouping. IEEE 2nd international Conference on Education Technology and Computer (ICETC), 121-123.

Lu, C. S. (2005). Multimedia Security, Steganography and Digital watermarking Techniques for Protection of Intellectual Property. Idea Group Publishing.

Mabtoul, S., Elhaj, E. h. I., & Aboutajdine, D. (2007). Robust color image watermarking *based on s*ingular value decomposition and Dual tree complex wavelet transform. *paper presented at IEEE International Conference on Electronics Circuits and Systems*, 534-537.

Maity, S. P., & Kundu, M. K. (2002). Robust and Blind Spatial Watermarking In Digital Image. *Proceedings of 3rd Indian Conf. on Computer Vision, Graphics and Image Processing (ICVGIP '2002). 16-18th December. Ahmedabad, India: 388-393.*

Maity, Delpha, C., & Pha*dikar, A. (2009).* Spread-Spectrum Watermarking Security. *IEEE International Conference on Multimedia Information Networking and Security, 525-529.*

Macq, B. M., and Quisquater, J. J. (1995). Cryptology for Digital TV Broadcasting. *Proceedings of the IEEE. June. 83(6): 944-957*.

Massey, J. (1988). An introduction to contemporary cryptology. *Proceedings of the IEEE*. May. 76(5): 533– 549.

Mayer, J. o. (2011). Improved Spread Spectram Multibit Watermarking. *IEEE International Workshop on Information Forensics and Security (WIFS), 1-6.*

Megalingam, R. K., Nair, M. M., Srikumar, R., Balasubramanian, V. K., & Sarma, V. S. V. (2010). Performance Comparison of Novel, Robust Spatial Domain Digital Image Watermarking with the Conventional Frequency Domain Watermarking Techniques. IEEE International Conference on Signal Acquisition and Processing, 349-353.

Modaghegh, H, .H, K., & Akbarzadeh, M. (2009). A new adjustable blind Watermarking based on GA and SVD. IEEE,6th International Conference on Innovations in Information Technology, 6-10.

Mohamed, M., Afari, F., & Bamatraf, M. (2011). Data Hiding by LSB Substitution Using Genetic Optimal Key-Permutation. International Arab Journal of e-Technology, vol. 2, no. 1, 11-17.

Mohammad, A. M. F., & Asad, N. M. (2006). An Optimization Approach for Selecting Blocks of Embedding Process in Robust Watermarking System. *Journal of Computer Science 2 (1) ISSN 1549-3636 © 2006 Science Publications*, 114-117.

Mukherjee, D. P., Maitra, S., & Acton, S. T. (2004). Spatial Domain Digital Watermarking of Multimedia Objects for Buyer Authentication. *IEEE Transactionson multimedia*, vol. 6, No. 1, 1 - 15

Nasir, I., Weng, Y., & Jiang, J. (2007). A New Robust Watermarking Scheme for Color Image in Spatial Domain. *Third International IEEE Conference on Signal-Image Technologies and Internet-Based System SITIS '07*, 942-947.

Okagaki, K., Takahashi, K., & Ueda, H. (2010). Robustness Evaluation of Digital Watermarking Based on Discrete Wavelet Transform. *IEEE Sixth International*

Conference on Intelligent Information Hiding and Multimedia Signal Processing, 114-117.

Pal, G. Ghosh and M. Bhattacharya, (2012). Reversible Digital Image Watermarking Scheme Using Bit Replacement and Majority Algorithm Technique. *Journal of Intelligent Learning Systems and Applications,* Vol. 4 No. *3*, 199-206.

Pan, G., Wu, Z., and Pan, Y. (2002). A Data Hiding Method for Few-color Images. *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP'02).* 13-17 May. Orlando, Florida: 3469-3472.

Pérez-Freire, L., & Pérez-González, F. (2009). Spread-Spectrum Watermarking Security. IEEE Transections on Information Forensics and Security, Vol. 4, No. 1, 2-24.

Parameswaran, L., and Anbumani, K. (2006). A Robust Image Watermarking Scheme using Image Moment Normalization. Transactions on Engineering, Computing and Technology. May. 13, ISSN 1305-5313.

Perumal, S. M., & Kumar, V. V. (2011). A Wavelet based Digital Watermarking Method using Thresholds on Intermediate Bit Values. International Journal of Computer Applications, Vol 15 No.3, 29-36.

Peungpanich, A., Areewan, Mettripun, N., & Amornraksa, T. (2010). Improved Image Watermarking Using Image Averaging Technique and Prediction of Tuned Watermarked Pixels. 2nd International Conference on Information Engineering and Computer Science.

Peungpanich, A., & Amornraksa, T. (2010). An Improving Method for Image Watermarking Using Image Averaging and Tuned Pixels Prediction. *IEEE,ISCIT, 755-760.*

Petitcolas, F. A. P., Anderson, R. J., and Kuhn, M. G. (1999). Information Hiding-A survey. *Proceedings of the IEEE. 87(7): 1062 -1078.*

Pieprzyk, J., Okamoto, E., and Seberry, J. (2000). Spatial-Domain Image Watermarking Robust against Compression, Filtering, Cropping, and Scaling. *ISW 2000, LNCS 1975, Berlin Heidelberg*. *Springer-Verlag*: 44–53.

Podilchuk, C. I., & Zeng, W. (1998). Image-Adaptive Watermarking Using Visual Models. IEEE Journal on selected Areas In Communacations Vol 16 No 4, 525-539.

Podilchuk, C. I., & Delp, E. J. (2001). Digital watermarking: algorithms and applications. IEEE Signal Processing Magazine, Vol 18(Iss 4), 33-46.

Qi, J. (2005). A rotation, scaling, and translation-resilient digital watermarking scheme based on image content. Master Thesis. Computer Science, UTAH State University.

Ramani, K., Prasad, E. V., Varadarajan, S., & Subramanyam, A. (2008). A Robust Watermarking Scheme for Information Hiding. *Advanced Computing and Communications, 16th International Conference,* 58-64.

Rohith, S. & Bhat, K. N. H. (2012). A Simple Robust Digital Image Watermarking against Salt and Pepper Noise using Repetition Codes. ACEEE Int. J. on Signal & Image Processing, Vol. 03, No. 01, 47-54.

Saxena, V. (2008). Digital Image Watermarking. *Phd thesis submitted to Jaypee Institute of Information Technology University, Inoida, India.*

Schneier, B. (1996). Applied Cryptography. (2nd ed.). New York, NY: John Wiley & Sons, Inc.

Schyndel, V. R. G., Tirkel, A. Z., & Osborne, C. F. (1994). A digital watermark. Proceedings of IEEE Int. *Conference on Image Processing. Austin, Texas, USA: 86–89.*

Seddik, H., Sayadi, M., Fnaiech, F., & Cheriet, M. (2003). A New Spatial Watermarking Method, based on a Logarithmic transformation of An Encrypted embeded Mark. 1-6.

Shelby, P. (2000). Robust Digital Image Watermarking. *Ph.D. Thesis. University of Geneve, Faculty of Science, Canada.*

Shih. (2010). Image Processing and Pattern Recognition:Fundamentals and Techniques *Wiley-IEEE Press eBook Chapters* 444-473.

Simmons, G. (1992). Contemporary Cryptology: The Science of Information Integrity. *Piscatoway, NJ: IEEE Pres*s.

Singh, R., & Gupta, R. (2011). Digital Watermarking with Visual Cryptography in Spatial Domain. *International Conference on Advanced Computing, Communication and Networks'11*, 948-951.

Song, C., Sudirman, S., & Merabti, M. (2010). Robust Digital Image Watermarking using Region Adaptive Embedding Technique. *paper presented at IEEE International Conference on Progress in Informatics and Computing (PIC), vol 1*, 378-382.

Song, C., Sudirman, S., Merabti, M., & Llewellyn-Jones, D. (2010). Analysis of Digital Image Watermark Attacks. *paper presented at 7th IEEE Computational Consumer Communications and Networking Conference (CCNC)* 1-5.

Swanson, M. D., Bin, Z., and Tewfik, A. H. (1996). Transparent Robust Image Watermarking. *Proceedings of the IEEE International Conference on Image Processing.* September. Lauzanne: 211-214.

Tao, P., & Eskicioglu, A. M. (2004). A Robust Multiple Watermarking Scheme in the Discrete Wavelet Transform Domain. *Optics East, Internet Multimedia Management Systems V Conference*.

Thanikaiselvan, Arulmozhivarman, Amirtharajan, R., & Balaguru, J. B. (2011). Wave(Let) Decide Choosy Pixel Embedding for Stego. *paper presented at IEEE International Conference on Computer, Communication and Electrical Technology – ICCCET*, 157-162.

Thapa, M., & Sood, S. (2011). On Secure Digital Image Watermarking Techniques. Journal of Information Security, volume 2 number 4, 169-184.

Tripathi, S., Ramesh, N., Bernito, & Neeraj. (2010). A DWT based Dual Image Watermarking Technique for Authenticity and Watermark Protection. Signal & Image Processing : An International Journal (SIPIJ), Vol.1, No.2, 33-45.

Tsai, Y., Y., Chen, J., T., and Chan C., S. (2014). Exploring LSB Substitution and Pixel-value Differencing for Block-based Adaptive Data Hiding. *International Journal of Network Security*, Vol.16, No.5, 363-368.

Voyatzis, G., and Pitas, I. (1998). Chaotic watermarks for embedding in the spatial digital image domain. *Proceedings of IEEE Int. Conf. Image Processing*. Chicago, IL, USA. 2: 432–436.

Wang, C. C., Tai, S. C., & Yu, C. S. (2000). Repeating Image Watermarking Technique by the Visual Cryptography. IEICE Trans. Fundamental. August. E83-A(8): 1589-1598.

Wang, R. Z., Lin, C. F. and Lin, J. C. (2001). Image hiding by optimal lsb substitution and genetic algorithm. Pattern Recognition. 34(3): 671–683.

Wang, Y., and Pearmain, A. (2004). Blind Image Data Hiding Based on Self Reference. *Pattern Recognition, 25: 1681-1689.*

Wu, C. F. (2001). The Research of Improving the Image Quality of Digital Watermarking Technique and Its Applications. *National Sun Yat-sen University, Kaohsiung*, 80424, Taiwan. etd-0612101-142904.

Wu, D. C. and Tsai, W. H. (2003). A steganographic method for images by pixelvalue differencing, Pattern Recognition Letters. 24(9-10): 1613–1626.

Wu, N. I., and Hwang, M. S. (2007). Data Hiding: Current Status and Key Issues. *International Journal of Network Security. January*. 4(1): 1–9.

Xiong, Z., Sun, X., & Wu, F. (2010). Robust Web Image/Video Super-Resolution. *paper presented at IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 19, Issue: 8*, 2017-2028.

Yang, S. L., & Zhang, Z.B. (2009). Digital Image Watermarking Using Iterative Blending Based on Wavelet Technique *paper presented at IEEE International Conference Multimedia Information Networking and Security (MINES), Vol 2*, 83-86.

Yin, C. Y., Wu, D. C., and Tsai, W. H. (2002). New data hiding methods for copyright protection, annotation, and authentication of BMP archive images in digital libraries and museums. *Proceedings of the 1st Workshop on Digital Archives Technologies.* Taipei, Taiwan, Republic of China: 168-183.

Yongqiang, C., Yanqing, Z., & Lihua, P. (2009). A DWT Domain Image Watermarking Scheme Using Genetic Algorithm and Synergetic Neural

Network. *International Symposium on Information Processing (ISIP'09), ISBN 978-952-5726-02-2*, 298-301.

Yusof, Y., & Khalifa, O. O. (2007). Digital watermarking for digital images using wavelet transform. *EEE International Conference on Telecommunications and Malaysia International Conference on Communications*, 665-669.

Zamani, M., Manaf, A. A., Ahmad, R., Zeki, A., & Abdullah, S. (2009). A Genetic-Algorithm-Based Approach for Audio Steganography. *International Conference on Communities and Communications World Academy of Science, Engineering and Technology 54, ISSN: 2070-3740.*, 359-363.

Zamani, M., Manaf, A. A., Ahmad, R., Zeki, A., & Abdullah, S. (2009). Genetic Algorithm as an Approach to Resolve the Problems of Substitution Techniques of Audio Steganography. *International Conference on Genetic and Evolutionary Methods SBN: 1-60132-106-6 and 1-60132-092-2. . Las Vegas, Nevada, USA*, 170-175.

Zamani, M., Taherdoost, H., Manaf, A. A., Ahmad, R., & Zeki, A. M. (2009). Robust Audio Steganography via Genetic Algorithm. *Third International Conference on Information & Communication Technologies ICICT*, 149 - 153.

Zeki, A. M., & Manaf, A. A. (2009). A Novel Digital Watermarking Technique Based on ISB (Intermediate Significant Bit. *World Academy of Science, Engineering and Technology 50*, 989-996.

Zeki, A. M., Manaf, A. A., & Mahmod, S. S. (2011). Improving the robustness of ISB watermarking techniques by repetition of the embedding. *In: Communications in C*omputer and Information Science. Springer-Verlag Berlin Heidelberg, 592-599.

Zeng, W., & Wu, Y. (2010). A Visible Watermarking Scheme in Spatial Domain Using HVS Model. Information Technology Journal 9 (8) ISSN 1812-5638, 1622-1628.

Zhang, F., & Zhang, H. (2004). Applications of neural network to watermarking capacity IEEE International Symposium on Communications and Information Technology ISCIT, Vol 1, 340-343.